I. Biological membranes are lipid bilayers with associated proteins
   A. Phospholipids form bilayers in water
      1. Phospholipids have two fatty acid chains linked to a glycerol molecule
      2. The hydrophilic portion of the molecule is the phosphate bonded to the glycerol
      3. The fatty acids make up the hydrophobic portion of the molecule
      4. The molecule is amphipathic
         a. The bilayer forms spontaneously because of the amphipathic characteristic
         b. Many common detergents are also amphipathic, and so are able to “solubilize” oil
   B. Current data support a fluid mosaic model of membrane structure
      1. Davson and Danielli (1935)– phospholipids form a membrane two molecules thick; the lipid bilayer
      2. Singer and Nicholson (1972)– the fluid mosaic model
      3. This membrane is only 10 nanometers thick
      4. Various types of proteins move around like icebergs in the lipid sea
   C. Biological membranes are two-dimensional fluids
      1. Phospholipids act as liquid crystals, and the molecules move laterally
      2. Molecules rarely move from one side of the membrane to the other
      3. Frye and Ediden (1970) demonstrated movement of proteins in the membrane
      4. Various may occur between hydrocarbon chains
         a. Saturated fats lack double bonds in the fatty acid chains, causing the membrane to be less fluid
         b. Organisms may alter the proportion of saturation in response to temperature
      5. In animal cells, cholesterol, which is slightly amphipathic, stabilizes the membrane at higher temperatures
      6. In plant cells, other steroids function in a similar manner
   D. Biological membranes fuse and form closed vesicles
      1. Membrane fusion is due to the liquid crystalline state
      2. When vesicles and another membrane fuse, their bilayers and lumens become continuous
      3. Endocytosis and exocytosis are a product of membrane fusion
   E. Membrane proteins include integral and peripheral proteins
      1. Integral proteins are firmly bound to the membrane, or bound to other lipids that are part of the membrane
      2. Transmembrane proteins span the entire bilayer
         a. Most transmembrane proteins span the membrane only once, but some may even weave back and forth a number of times
b. Transmembrane proteins are amphipathic

3. Peripheral proteins are bound to the hydrophilic ends of the integral proteins

F. Proteins are oriented asymmetrically across the bilayer
   1. Evidence comes from freeze-fracture electron microscopy
   2. Proteins are produced in the ER, then pass to the Golgi, then via a vesicle to the plasma membrane

G. Membrane proteins function in transport, information transfer, and as enzymes
   1. Proteins are involved in transport of small molecules
   2. Enzymes may be embedded in the membrane
   3. Receptor proteins are embedded in the exterior surface of the membrane
      a. Signal molecules convert an extracellular signal into an intracellular signal via signal transduction

II. Cell membranes are selectively permeable
   A. Most biological membranes are permeable to small or lipid-soluble molecules
      1. Water molecules may pass the lipid bilayer
      2. Gases, small polar molecules and large hydrophobic substances may also pass
      3. Other molecules move through special channels
   B. Random motion of particles leads to diffusion
      1. Atoms and molecules above absolute zero exhibit motion
      2. Due to random motion, particles move from an area of higher concentration to lower concentration, ultimately reaching equilibrium
      3. The rate of diffusion depends on temperature, size of the molecules, electrical charges, and concentration gradient
      4. Dialysis is the diffusion of a solute across a selectively permeable membrane
         a. Kidney dialysis removes wastes from the blood when the kidneys are not functioning properly
      5. Osmosis is the diffusion of water (solvent) across a selectively permeable membrane
         a. The osmotic pressure is the tendency of water to move into that solution
         b. Two solutions may be isotonic to each other, or one may be relatively hypertonic and the other relatively hypotonic
            1). Human cells are isotonic with a 0.9% sodium chloride solution
            2). Solutions which are hypertonic have a higher osmotic pressure than the cells; solutions which are hypotonic have a lower osmotic pressure than the cells
               a). Animal cells placed in a hypertonic solution tend to crenate
               b). Plant cells placed in a hypertonic solution tend to plasmolyze

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c). Animal cells placed in a hypertonic solution tend to swell and burst
d). Plant cells placed in a hypertonic solution tend to become turgid

3). Turgor pressure is the internal hydrostatic pressure usually present in walled cells
   a). Turgor pressure provides structural support in non-woody plants

C. Carrier-mediated transport of solutes requires special integral membrane proteins
   1. Impermeability of the cell membrane is advantageous so cells do not tend to lose valuable polar molecules
   2. Two forms of carrier-mediated transport are facilitated diffusion and carrier-mediated active transport

D. Facilitated diffusion occurs down a concentration gradient
   1. A membrane may become permeable by a protein that combines with the material to be transported
   2. Glucose transport across erythrocyte membranes is an example
   3. Liposomes are artificial vesicles which have been used to study facilitated diffusion

E. Some carrier-mediated active transport systems "pump" substances against their concentration gradients
   1. Materials are transported from a region of low concentration to high by carrier-mediated active transport mechanisms
   2. ATP is required
   3. The sodium-potassium pump is an example
   4. Other mechanisms involve the pumping of ions in photosynthesis and aerobic respiration

F. Linked cotransport systems indirectly provide energy for active transport
   1. These transport systems cotransport molecules against their concentration gradient
   2. ATP is a requirement for linked cotransport systems
   3. Example: glucose transport across microvilli of the intestine
   4. More than one transport system may transport one substance

G. Facilitated diffusion is powered by a concentration gradient; active transport requires another energy source
   1. The energy of ATP is used directly or indirectly in transport of materials

H. In exocytosis and endocytosis large particles are transported by vesicles or vacuoles
   1. In exocytosis, the cell expels wastes or a secretory product
      a. Exocytosis also results in growth of the cell membrane
   2. In endocytosis, a cell takes up materials
      a. Phagocytosis involves taking in solid materials
      b. Pinocytosis involves taking in liquid droplets
   3. Receptor-mediated endocytosis involves receptor proteins binding to the material to be engulfed
      a. Molecules bind to receptors called ligands concentrated in coated pits
      1). Coated pits are coated by a protein, clathrin
b. The coated pits move inwards via endocytosis and are termed coated vesicles
c. The coated vesicle ultimately becomes an endosome when the coating is lost
d. Cholesterol is taken into cells by this pathway

1). Brown and Goldstein—1986 Nobel Prize

III. Junctions are specialized contacts between cells

A. Desmosomes are points of attachment between some animal cells
   1. Desmosomes hold cells subject to mechanical stresses together
   2. Desmosomes are composed of intermediate filaments which span the gap between two cells

B. Tight junctions seal off intercellular spaces between some animal cells
   1. Tight junctions seal cells tightly with protein links
   2. Tight junctions are important in epithelia

C. Gap junctions permit transfer of small molecules and ions
   1. Gap junctions contain pores that connect cells
   2. Proteins form the pores
   3. Gap junctions allow rapid communication between cells
   4. The apertures of gap junctions may be controlled

D. Plasmodesmata allow movement of certain molecules and ions between plant cells
   1. Plasmodesmata are connections between plant cells
   2. Plasma membranes are continuous through the plasmodesmata
   3. A desmotubule may connect the ER of adjacent cells
   4. Typically, molecules but not organelles pass through plasmodesmata